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DEVELOPMENT AND PRESENT CONDITION OF SEWAGE TREATMENT AND UTILI--ETC(U)

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DEVELOPMENT AND PRESENT CONDITION OF SEWAGE TREATMENT AND UTILIZATION IN BERLIN

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This report is a thorough description of the development of the sewage treatment and utilization system of the city of Berlin, Germany as of 1955.

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THE DEVELOPMENT AND PRESENT CONDITION OF SEWAGE TREATMENT AND UTILIZATION IN BERLIN

by Kurt Weiland, Engineer, Berlin DK 628.2:626.84

By mid-Nineteenth Century, though pure water facilities had already been established, the ever-increasing accumulation of sewage, together with a lack of hygiene and high mortality rate caused by typhus and other infectious diseases necessitated the creation of facilities for regulating and disposing of back-water from private households and industrial concerns in the growing Berlin Metropolis. The following is a thorough description of the development of the sewage treatment and utilization system of the City of Berlin.

The Sewage Farms

The struggle for the sewage regulating and disposal system of the City of Berlin spans several decades. The real turning point occurred when tests conducted from 1870 to 1872 demonstrated that favorable results could be achieved by purifying back-water and using the fertilizer contained therein to an agricultural advantage, i.e., by channeling the so-called liquid manure on land used for farming. As a test site, a plateau of barren soil was chosen at Tempelhof Field. Using the same procedure which had previously been tried in Croydon, England, involving an actual waste water processor, tests were devised and made ready for execution. The observations made in England, however, did not fully apply to the conditions in Berlin. Consequently, more appropriate channeling and damming techniques were tried and developed.

Upon completion of the tests, results showed that ground water pollution need not be reckoned with if the irrigated surface were dammed at set limits and that, moreover, a high degree of back-water purification could be expected in the upper layer of soil. Agricultural productivity on the irrigated planes of the test site seemed especially favorable. Grass yield was excellent while fodder tests, conducted by the Veterinary College of Berlin indicated an abundance of nutritious fodder which could be adopted and fed to livestock without any deleterious effect. Various types of cabbage, beans, peas, potatoes, corn, etc. thrived excellently and were significantly superior when compared to the agricultural yield of unirrigated land of that era.

Plans for the construction of the sewage system for the City of Berlin were drawn up by Virchow and Hobrecht. The positive results of the tests conducted at Tempelhof Field convinced even the staunchest opponent so that, by 1873, a decision was reached to construct a drainage system for the City of Berlin, based on the combined system and the purification of processed domestic and industrial waste on sewage farms, which would include rainwater. This provided the basis for the processing of waste quantities emanating from the City while it equally provided the incentive to apply new scientific and agricultural techniques of the time as a standard for waste purification and utilization processes.

In accordance with the approved plan, the City area was divided into 12 independent drainage zones (radial systems), each zone being assigned its own gradient conduit system and feed pump unit. The first such system, radial system III, equipped

with a pumping unit, was laid in Schöneberg Street in May 1873. A cast iron pressure pipe was laid which ran from the pumping unit to the already established sewage farm of Osdorf.

On January 1, 1878, control of pumping station III, with its attendant conduit system, pressure pipe and sewage farm was assumed by Berlin's first drainage system director -- a date which marks the beginning of Berlin's sewage treatment and utilization system.

While Berlin's drainage system steadily expanded and the number of land areas connected to completed conduit systems increased, it was essential that other sewage treatment plants be constructed. Consequently, the area of Falkenberg and the farmlands of Bürknersfelde (1875), the properties of Heinersdorf and Grossbeeren (1881), Blankenfelde and Malchow (1882), etc. were purchased by the City for the purpose of sewage processing.

By 1878 approx. 2,000 hectares were reserved for this purpose (216 of which were actually sewage-processed).
By 1893 approx. 9,000 hectares were reserved for this purpose (4,670 of which were actually sewage-processed).
By 1909 approx. 17,500 hectares were reserved for this purpose (8,500 of which were actually sewage-processed); and from 1915 to 1920, approx. 18,000 hectares were reserved for this purpose (8,650 of which were actually sewage-processed).

The area dimensions cited above comprise the sum total of drainage area, including wooded and/or brush areas.

With the establishment of the "Municipality of Berlin" in 1920, following the consolidation of the City Proper with its suburbs, sewage farms of several districts were assigned to the centralized City drainage system, involving pumping stations, pressure pipes and sewage treatment plants. These were:

Charlottenburg	Karolinenhöhe sewage farm
Spandau	Wansdorf sewage farm
Pankow	Mühlenbeck sewage farm
Friedrichsfelde	Münchehofe sewage farm
Schöneberg and Friedenau	Deutsch-Wusterhausen sewage farm
Neukölln	Wassmannsdorf/Boddinsfelde sewage farm
Steglitz and Lichtenrade	Kl.-Ziethen sewage farm
Gross-Lichterfelde	Werben sewage farm

For similar reasons and at the same time, the sewage farms of Schönerlinde, Birkholz bei Blumberg, Tasdorf, Gr.-Ziethen and Diedersdorf, equipped with conduit systems, were placed under the jurisdiction of the Municipal Drainage System. These sewage networks, constructed at that time, were connected to networks of other municipalities for the purpose of efficiently solving each, individual problem of waste disposal and purification as it arose, covering the entire interconnected system.

When the City of Berlin became consolidated with its suburbs in 1920, 44 municipalities and landed districts were serviced by sewage farms while six municipalities were serviced by waste purification plants. The six purification plants, including, most prominently, the percolating filter installation, the

latter having been constructed to service the sewage network in Stahnsdorf, covering Wilmersdorf, Schmargendorf, Zehlendorf and Teltow, were discontinued by the end of 1927. From that date, all drainage-sewage emanating from the City of Berlin was processed on sewage farms. The aforementioned consolidation also produced further changes to existing facilities, now that it became possible to abolish a number of installations and contrivances both in terms of efficiency and economy. Areas so affected were assigned to other waste purification plants. At that time, the Gross-Lichterfelde sewage farm of Werben was also abolished owing to its unfavorable location vis-à-vis the City of Berlin.

In 1928, 50 years after the drainage system for the City of Berlin had been implemented, the amount of land area purchased by the City for sewage purification to be processed by the Municipal Drainage System covered 23,036 hectares, excluding woodlands. Of these, 10,708 hectares were adapted, i.e., specifically designed for drainage while the remaining areas were used for approach lanes, channels, natural reserves, courtyards, gardening and water surfaces.

After 1928, the total area was extended by the purchase of the estate properties of Vogelsdorf, Brusendorf, Schöneiche and Selchow and the Schenkenhorst acreage. At the same time, however, the sewage farm regions of Tasdorf and Deutsch-Wusterhausen were forced to make way for the State <u>autobahn</u> then being constructed. While Tasdorf consisted almost entirely of wooded countryside, the converted areas of Deutsch-Wusterhausen were severely affected by these measures.

Construction priority of the State <u>autobahn</u> at a time when new areas were being

claimed for this purpose, i.e., both during and after World War II, took considerable toll of the sewage farm regions of Wansdorf, Blankenfelde, Mühlenbeck, Schönerlinde, Buch, Malchow, Falkenberg, Sputendorf, Grossbeeren and Kl.-Ziethen/Selchow. Other territorial losses were incurred after 1945 when various sewage farm areas were reclaimed for land reform on a selective basis.

By 1953, the irrigated areas used for farming by the Vereinigung Volkseigener Güter Grossberlin (Collectivity of Individual Properties of Greater Berlin) and their tenants comprised a total area of approx. 17,900 hectares. This cluded the following regions:

Wansdorf

Karolinenhöhe - in part -
(2/5 of the area lies in the British Sector of Berlin)

Blankenfelde, including the regions of Buchholz, Rosenthal, Möllersfelde and Lindenhof

Mühlenbeck

Schönerlinde

Buch

Hobrechtsfelde

Malchow, including the regions of Blankenburg and Wartenberg

Falkenberg, including Bürknersfelde

Hellersdorf

Münchehofe

Tasdorf

Sputendorf, including the regions of Güterfelde, Schenkenhorst, Struweshof and Fahlhorst

Grossbeeren, including the regions of Neubeeren and Ruhlsdorf

Osdorf, including the regions of Heinersdorf, Birkholz, Friederikenhof, Kleinbeeren and Diedersdorf

Gross-Ziethen

Kl.-Ziethen, including Selchow

Wassmannsdorf

Boddinsfelde

Deutsch-Wusterhausen

Of the above total area of sewage farms, 9,900 hectares of converted area are presently being used for sewage processing with the remaining area being reserved for approach lanes, channels, natural reserves, courtyards, gardening and water surfaces. Of the natural reserve areas, a total stretch of approx. 1,600 hectares has been provided with conduits to process the sewage containing natural fertilizer during the autumn and winter months.

Both the results of the tests conducted at Tempelhof Field and the sum/of the experience since gained from the initial sewage farm at Osdorf have set the general standard to be applied to scientifically designed sewage farms. Areas intended for sewage processing, often being hilly, have had to be dealt with in particular. Making allowances for the essential approach lanes, the entire irrigated area was divided into lots, each averaging .25 hectares and limited by miniature dams. These irrigated areas, .35 to .5 hectares in size, connected to the former Boddinsfelde sewage farm at Neukölln. Approx. 10 to 15 interconnected lots comprise one sewage processing zone, which is surrounded by country roads. Illustration 1 shows a general view of this zoning distribution.

In order to obtain the most uniform back-water distribution possible within each zone at the lowest cost for operation, each lot was formed as a horizontal

or inclined plane depending on its topographical features. To construct the adapted surfaces considerable excavation was required in certain areas. With former sewage, the ratio between inclined and level surfaces was 1:3. In more recent sewage farms attempts have been made to reduce the incidence of incline as far as possible; otherwise, with operational conditions as they are, a sufficiently uniform distribution of sewage irrigation cannot be achieved.

In order to contain the quantity of waste material rendered during periods of frost and extensive rainfall without adversely affecting the natural environment of the sewage farms, dam basins, measuring 5 to 8 hectares in size, were provided, taking into account the peculiar features of each sewage farm. No farming was to be carried out on these basins. At present, however, a number of them are being used for agricultural purposes.

The pressure pipes connecting the City to the sewage farms were run to the highest level of a sewage farm, terminating at that point, with a few exceptions, in a vertical pipe equipped with a spillway. These vertical pipes serve a dual purpose, acting first as a safety valve for the pumps and pressure pipe conduits and secondly as a signal-device carrier, the device of which may be read by the sewage farm custodian (1). Two permanent markings appear on the vertical pipe: one indicating the highest water level in the pipe, the other the lowest water level. Between these two markings is a third fluctuating marking which is controlled by a floater. Judging from its position in relation to the permanent markings at any given time, the floater-gage indicates the rising and falling water level in the vertical pipe, thus enabling sewage farm personnel to regulate the distribution of the oncoming quantities of water by

opening and closing the discharge valve. By installing lighting facilities, the gages may be easily read even at night. From the vertical pipe the distribution conduits 800 mm max. in diameter traverse the sewage farm, terminating in a delta, each being equipped with a discharge valve (200 to 400 mm in diameter) at elevated land levels. These elevated levels are, however, dependent on the vertical pipe. Each discharge valve is further equipped with a settling basin in which sediment contained in the mechanically pre-purified waste is arrested, including the larvae of intestinal parasites.

When sewage farms were first established, no particular importance was attached to the arresting of bilge. It soon became evident, however, that the fresh silt contained in sewage was a detriment to farming. Discharge valves were therefore equipped with mud traps in the form of miniature soil basins secured by latticed walls to arrest the coarsest particles. The rigging of these settling basins later became increasingly important since the conduction of coarse or insufficiently purified sewage invariably resulted in silt-clogging the conduit trenches as well as the soil of the irrigated zones, especially in view of the relatively high work load enforced upon the sewage farms of Berlin. With the increase of population and proportionate increase of sewage, it has become necessary to improve mechanical purification processes even further.

Sewage farms later established, especially those found in the former suburbs, were equipped with technically perfected settling basins made of concrete, now that the experiences gained from the Berlin projects could be applied. Especially noteworthy are the settling basin facilities serving the Charlottenburg sewage farm at Karolinenhöhe with a pre-purification capacity to accommodate

the workload of each processing zone with an annual water column of 7 to 8 m, in conjunction with other modalities. The sewage farms of the former municipalities of Neukölln and Schöneberg at Boddinsfelde and Deutsch-Wusterhausen were also equipped with highly functional settling basin facilities and auxiliary silt-drying beds. One technical problem-solving method of special interest is represented by the radial basin at Boddinsfelde (see Illustration 2). The former city of Spandau erected a two-story Imhoff tank at Wansdorf with an efficient filtering system and excellent silt-processing facilities. The central purification plant, which was constructed to accommodate the Osdorf sewage farm, equipped with elaborate silt-drying beds, should also be noted, as well as the basin facilities at Münchehof and Tasdorf.

The increasing demand for hygiene in improving sewage purification methods with the disastrous effects of the belly worm epedemic in Darmstadt from 1946 to 1947, in particular, prompted the Berlin Drainage System principals to take greater care in constructing technical installations serving sewage farms. Consequently, a total of 28 new settling basins have been constructed since 1949; 40 basins and/or basin facilities have been placed under municipal jurisdiction and an additional 239 have been technically renovated and perfected as part of the current renovation plan, thus increasing purification capability.

At present, there are 654 settling basins of various construction in operation, covering the sum total of sewage farms serving the City of Berlin. The settling cycle for said basins ranges from 1 to 1-1/2 hours, while the degree of purification obtained for disposable matter is 70 to 95%.

Included in the project to construct new settling basins and improve existing facilities was the establishment of numerous silt-drying beds equipped with an elaborate drainage system which, during the summer months, would ensure rapid drainage lasting approx. two months and the drying of stagnant silt from the basins. A unique method was developed to construct the settling basins for the northeastern sewage farms located within the City limits, viz., Malchow, Falkenberg and Hellersdorf, the operation of which was to be eventually discontinued following the change-over of waste purification plants as a result of the reconstruction and enlargening of Berlin. Inlets and outlets, including the revetment of the slopes were made of manufactured concrete slabs. When disassembled, the same slabs could be used, e.g., for constructing new waste purification plants elsewhere (see Illustrations 3 and 4).

It has been proven that, if the basins are to function properly, concreting of the basin floor and the construction of mud channels are absolutely essential. This means, of course, higher construction costs; at the same time, however, there is a considerable saving owing to the fact that costs for emptying each basin separately are greatly reduced.

Recent tests which have been conducted to purify sediment have pointed to a new method of constructing inlets and inovations as to the slope of the settling basins. Up to now, the ratio between width and length in existing facilities had been approx. 1:2. In the future, new basins shall have a width-length ratio of 1:4. The inlet channels of basins which, in present installations, function as a sand and silt trap shall be constructed in the future with tapering sectional areas, taking into account their existing hydraulic ratio

from inlet to outlet. In this way, the most uniform flow possible entering the basin will be obtained so that the oncoming sewage may be more evenly distributed over the spillway.

After traversing the settling basin, the pre-purified sewage reaches a baffle which, in turn, arrests the existing floating silt. It then flows beneath the baffle and over a spillway and finally into an exposed distribution channel.

Since the more antiquated basins have no drying beds, the silt emptying into the pre-purification facility on the sewage farm must be scooped out by hand. In modern installations, however, the silt is deposited on drying beds. After it is thoroughly drained, the silt is converted into durable fertilizer and may be sold, as in the case of silt salvaged from the older basins.

The mechanically pre-purificed sewage is conducted from the settling basins to exposed ducts leading to the sewage farm processing zones, thence to the individual lots. Adjustable inlets called "Drummen" (culverts) with covers or casings, allow the sewage found in the ducts to enter the individual lots. While it is relatively easy to monitor the damming of horizontal lots, the run-off on inclined surfaces must be closely observed. In the latter, water is conducted into a channel located on the upper surface side, the border of which must run horizontally to the run-off surface so that the water will run over the slope at a steady flow. It will be up to the custodian to see to it that the sewage flow is regulated so that the run-off surface is evenly covered and that no damming occurs at the lower border.

On the whole, the Berlin sewage farms have a light, sandy soil with relatively

favorable permeability. Nonetheless, continuous draining of the irrigation lots, except in some cases, cannot be ignored since the level of ground water rises very easily with frequent damming of the irrigation lots, which may result in lowering the effective level of natural biological cleansing agents found in the upper soil stratum. Consequently, drains have been provided to ensure thorough biological purification as well as to accelerate the sewage process. To a certain extent, the drains further act as soil ventilators, thus accelerating the biological processes of the upper soil stratum.

The sewage farm surfaces are equipped with suction devices 5 cm in diameter, secured in the ground at depths of 1.25 to 1.50 m and spaced 4 to 6 m apart. The suction devices are connected to collectors 8 to 15 cm in width, which flush the drain water through main collectors into exposed trenches. The present drains run approx. 16,000 km in total.

To accommodate the drain water, approx. 660 km of trenches incised at depths of 1.5 to 5 m were provided for the sewage farms. At certain points, the main trenches go even deeper. One such trench has, in fact, a depth of 18 m. The fixed contour of the trenches is invariably rectangular and is reinforced throughout by means of fascines and pre-driven pilings. Depending on local conditions (e.g., the direction of liquid flow, etc.), the contour of the trench is formed by 1 to 3 layers of fascines. The trenches must be maintained on a continuous basis. Due to a shortage of manpower and material prior to, during and after World War II, maintenance work in several areas was delayed. In an effort to restore the trench network on a gradual basis, the Berlin Drainage System has directed that repairs to the trenches should be executed on a grand scale without interruption. In the year 1952 alone, 23.7 m of trenches were

provided with new fascines. To ensure proper functioning, the trenches must be re-sloped regulated and cleared of weeds and sand each year. During sand removal operations in 1952, 48,000 m^3 of sands in terms of productivity was removed from the trenches by private workers.

In order to ensure that drain water is properly conducted, it had been necessary to construct a series of main canals during the past 25 years. Consequently, the Wuhle, serving as a main canal for the sewage farms of Falkenberg and Hellersdorf, was fortified by a layer of fascines, extending to 14.2 km. To accommodate Falkenberg, the Marzahn-Hohenschönhaus border canal was also fascine-fortified extending to 5 km and the southern sea canal extending to 5.1 km. The water conduit system of the Mahlow sea canal, a main canal serving the sewage farm of Osdorf, was fitted with concrete cut-off walls extending to 3.6 km, the upper portion of which was reinforced by steel/concrete girders and cross-bars (Cf. captioned illustration). The main drainage canal serving the sewage farm at Boddinsfelde was similarly outfitted extending to approx. 1 km; however, in this instance, steel frame reinforcements and concrete slabs were used. The Ziethen-Rudower canal, acting as a main canal for the sewage farms of Wassmannsdorf and Kl.Ziethen, while also accommodating the biologically purified sewage of the Wassmannsdorf purification plant, was reinforced with compressed concrete extending to 2.4 km. The principle drainage trench at Schenkendorf was fitted with cut-off planks (wooden) 8 cm in thickness extending approx. to 4.7 km. Originally, the trench emptied into the Stöckerfliess but was later re-channeled westward toward the Nuthe. This channel running 380 m was re-constructed using double-layered fascines and provided with sand traps measuring 52 m in length and 8 m in width. As a result of the renovation of the Nieder-Neuendorf-Paretz canal, the mouths of both main drainage trenches serving the sewage farm of Wansdorf have had to

be widened.

The biologically purified sewage which is conducted as drain water contains a relatively high degree of nutrients (nitrate), which stimulates plant growth in the trenches, thus requiring considerable weed-clearing operations. Before the drain water reaches the exposed main canals, it is conducted to various beds provided with ponds (flat soil basins). At this point, the sewage is biological pre-purified owing to the abundance of plant growth and flourishing micro-organisms. Furthermore, minute sand particles contained therein are diminished during the settling process being carried out by the basin. Detached fragments of plant growth (algae) etc. are arrested in the flow by improvised filters. The pre-purification ponds act, in part, as fish hatcheries. The drain water, which flows through said ponds, having lost considerable quantities of undesirable plant nutrients in the exposed main canals, is highly freed of suspended matter and pathological bacteria and may then proceed to the main canals without harmful effect.

Previously, drain water emanating from the post-purification plant at this point was used to irrigate the adjacent meadows during the summer months, if the conditions of the terrain so permitted. This so-called dual irrigation process resulted in the biological post-purification of sewage and produced greater grass yield.

Formerly, the sewage farms of Hobrechtsfelde, Malchow, Falkenberg and Boddinsfelde were provided with facilities, allowing the drain water to be pumped out of the drainage trenches and re-directed to the sewage farms whenever the need arose, especially during the season of optimal vegetation

growth. The latter farm was equipped with a permanent pumping station, while the other sewage farms were serviced by movable facilities provided by the local administration. In total, there were ten discharge pumping installations of this ty[illegible] time. By 1945, however, all had been put out of operation. [illegible] two permanent and seven movable installations have been put back into operation by local initiative. Other installations of this type will be provided for the landed areas. There are, moreover, a number of tenants operating installations to process the drain water.

Although the sewage flow of a metropolis is inconstant, it is a continuous round-the-clock process. It is, therefore, imperative that waste purification plants have the capacity to dispose of waste at any given moment. Accordingly, the Berlin sewage farms are operated in three shifts. Sheltering must be provided for sewage farm custodians having to perform their duties outdoors, both night and day and in all kinds of weather. It therefore follows that some kind of protective housing should be assigned to each district. The Drainage System of the City of Berlin has for some time sought to improve the social conditions of sewage farms, the highest priority of which has been the providing of appropriate shelter facilities for sewage farm custodians. To remedy this predicament, a total of 49 permanent and 21 movable shelters were provided for the northern and southern region sewage farms during the years 1949 to 1953. In addition, ten workshop units were constructed from 1949 to 1951 for the sewage farms of Blankenfeld, Malchow, Falkenberg, Hellersdorf, Münchchofe, Tasdorf, Sputendorf, Osdorf, Wassmannsdorf and Deutsch-Wusternausen, which included, aside from the workshop itself, storage rooms, lounges for personnel and special working areas for sanitary foremen. These workshop units greatly relieve the individual mechanic in maintaining the sewage farms.

CAPTIONS

Illustration 1

Lay-out of Falkenberg Sewage Farm

Explanation of Symbols

(a) Sewage Custodian Shelter

(b) Vertical Pipe (illegible)

(c) Pressure Pipe and Conduits with Escape Valve and Bassin

(d) Stop Valve

(e) Drainage Valve

(f) Silt-Drying Bed

Illustration 2

Settling Basin (Radial Basin) at Boddinsfelde Sewage Farm

Illustration 3

Outlet Side of the Settling Basin (Dual Bassin) at Tasdorf Sewage Farm

(Sewage Custodian Shelter shown in Foreground)

Illustration 4

Inlet Facilities of a Settling Basin of New Construction with Silt-Deposing Features Reinforced in part, using Manufactured Concrete Slabs

Illustration 5

Outlet of Settling Basin of New Construction Reinforced in Part using Manufactured Concrete Slabs